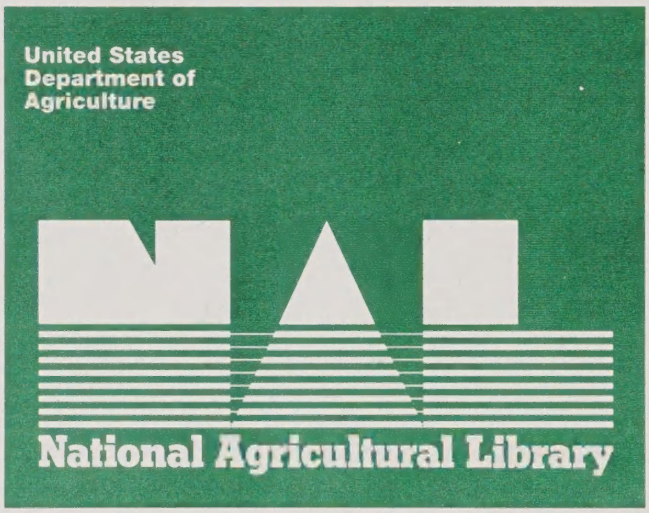
A National Program of Research for

TOBACCO

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES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FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The Task Force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The Task Force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the Task Force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

November 1968

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PREFACE

Background

The long-range study, "A National Program of Research for Agriculture," conducted by a joint USDA-SAES Task Force, was published in October 1966. The second recommendation of the study called for a more systematic and continuing mechanism that would facilitate joint research program planning, evaluation, and coordination. The Agricultural Research Planning Committee at its July and December 1966 meetings recommended the establishment of task forces to develop coordinated State-Federal plans for specified areas of research. Subsequently, thirty-two task forces were established of which this is one.

Authority

The Joint Task Force on Tobacco Research was appointed in memoranda of Dr. G. L. Mehren, Assistant Secretary of Agriculture, dated March 5, 1968 and Director A. G. Hazen, Chairman, ESCOP, dated March 5, 1968.

Membership

USDA -- E. L. Moore, Assistant Chief, Tobacco and Sugar Crops Research Branch, CR, ARS - co-chairman
L. B. Altman, Chief, Farm Electrification, AE, ARS
A. H. Baumhover, Leader, Tobacco Insects Investigations, Vegetable and Specialty Crops Insects Research Branch, ENT, ARS
A. H. Graves, Transportation and Facilities Research Division, ARS, Department of Agricultural Engineering, North Carolina State University, Raleigh, N. C. 27607
R. H. Miller, Acting Head, Tobacco and Specialty Crops Section, Economic & Statistical Analysis Division, ERS
G. R. Smith, Principal Agricultural Economist, CSRS
C. F. Woodward, Chief, Tobacco Laboratory, EU, ARS

SAES -- K. R. Keller, Assistant Director, In Charge of Tobacco Research Agricultural Experiment Station, North Carolina State University, Raleigh, N. C. 27607 - co-chairman
J. G. Alphin, Associate Professor of Agricultural Engineering, Clemson University, Pee Dee Experiment Station, P. O. Box 271, Florence, S. C. 29501
G. L. Bradford, Assistant Professor, Department of Agricultural Economics, University of Kentucky, Lexington, Kentucky 40506
P. D. Dukes, Associate Professor, Department of Plant Pathology, Georgia Coastal Plain Experiment Station, Tifton, Georgia 31794

SAES -- G. W. Stokes, Associate Director, Agricultural Experiment Station, University of Kentucky, Lexington, Kentucky 40506.
G. S. Taylor, Assistant to Director in Charge, Connecticut Agricultural Experiment Station, Valley Laboratory, P.O. Box 248, Windsor, Connecticut 06095.
T. R. Terrill, Assistant Professor of Plant Breeding, Department of Agronomy, Virginia Polytechnic Institute, Blackburg, Virginia 24061.

Advisors -- F. R. Darkis, Consultant, ARS, and former Vice-President and Director of Research, Liggett & Myers Tobacco Company, 3010 Surrey Road, Durham, North Carolina 27707.
Hans L. Falk, Associate Director for Laboratory Research, National Environmental Health Science Center, P.O. Box 12233, Research Triangle Park, N. C. 27709.

Staff Secretary -- Max Hinds and Axel L. Andersen, Research Program Development and Evaluation Staff, USDA

Dr. Andersen transferred to Michigan State University after making arrangements for the first meeting of the Task Force.

Assignment

This Task Force was asked to review and make recommendations with respect to research pertaining to tobacco included in the "National Program of Research for Agriculture" under research problem areas 207, 208, 209, 307, 308, 309, 405, 407, 408, 501, and 504.

SUMMARY

The Tobacco Industry:

- ranks fourth in cash receipts among farm crops
- ranks fourth among farm crops in export value
- provides a total income of 1.3 billion dollars for 625,000 farm families annually
- provides 4.1 billion dollars in tax revenue for Federal, State, and municipal governments.
- average annual increase of 3.7% in cigarette consumption in U. S. fell to about 1% after release of the Smoking and Health Report in 1964
- free world exports increased 23.2% from 1,434 million pounds during the period 1955-1959 to 1,767 million pounds in the period 1965-1967
- U. S. share of free world exports dropped from 35 to 30% during this period

Research Perspective:

- research on smoking and health and production efficiency improvement need priority treatment
- TF recommends a flexible research program

Protection: Goal II

- need to reduce huge losses from diseases and insects
- non-chemical means of disease and insect control can circumvent residue problems
- pesticides are needed which do not leave residues that may adversely affect quality or consumer use
- Combinations of cultural and chemical means of weed control should receive more attention

70% increase recommended for Goal II

Production: Goal III

- better breeding stocks are needed
- labor requirements are higher than for any other major crop
- an accelerated program for increasing efficiency is urgently needed to reduce labor requirements
- analyze systems approaches to determine physical, biological, and chemical inputs for maximizing net farm income
- develop genetic cultural and curing methods for improving quality constituents to enhance consumer acceptability and eliminate those which may be potentially hazardous
- high quality varieties adapted to mechanical culture are urgently needed

53% increase recommended for Goal III

Product Development and Quality: Goal IV

- reduce substances in cigarette smoke which may be deleterious without sacrificing flavor and aroma
- improved methods to determine tobacco and smoke constituents of major biologic or organoleptic importance
- need to determine chemical changes which occur during fermentation and aging
- improve cigar flavor and aroma and minimize pungent after odors
- quality deterioration in marketing channels should be prevented

93% increase recommended for Goal IV

Marketing: Goal V

- improvements needed in marketing system - essentially unchanged over many decades
- ideal grades and standards would enhance equity and communication between buyers and sellers

- handling, storing, and transporting are inefficient

- market structure - overbuilt in some places - yet inadequate to handle volume of sales at some peak periods

400% increase recommended for Goal V

I INTRODUCTION

Tobacco research programs have been joint ventures between USDA and SAES workers. These scientists have benefited from the close-working relationships and cooperation with scientists and leaf men from the purchasing and manufacturing segments of the industry. Only through continued cooperation of all these groups can the complex problems be solved for efficient production of a desirable quality product.

Total scientific effort devoted to the cooperative USDA-SAES programs in 1966 was 171 SMY's. The Task Force projection calls for an increase of 68 percent to 288 SMY's by 1977. However, in their deliberations, there was strong sentiment among members of the Task Force for substantial additional increases.

After further consideration, the Task Force agreed that through more teamwork the projected level of scientific man power could accomplish the objectives. Nevertheless, the rate of progress in the various RPA's cannot be predicted with certainty. For this reason, we recommend flexibility in the budgeting process to allow for any needed adjustments as research progress unfolds.

1. Crop Status

Tobacco, a major farm crop in the United States, consistently ranks fourth among crops in annual cash farm income. About 950,000 acres of land are planted to tobacco annually resulting in a crop valued at 1.3 billion dollars at the farm level. In recent years, about 1/3 of the crop has gone into export markets. Approximately 625,000 farm families depend wholly or in part on it for their livelihood. Many statistics could be cited to emphasize the economic importance of tobacco production such as monies expended for plant bed covers, farm equipment, pesticides, fertilizers, and curing fuels.

Tobacco production is a complex business. Careful planning and efficient execution are required if the grower is to prosper. The success of the farmer directly governs the economic welfare of the total industry. The truism is obvious; without capable growers, the tobacco industry could not exist. It follows, therefore, that any action predicated to revitalize and advance the tobacco industry must start with an understanding of the tobacco plant.

All phases of tobacco technology -- its breeding, its nutrition, its growth and physiology, its disease reaction, its susceptibility to insect attack, its curability, its quality assessment, its engineering of operations -- all are affected by complex and

interrelated processes that are extremely difficult to evaluate. A thorough understanding of the changes that take place within the tobacco plant from the planting of the seed through the acceptance of the cured leaf, i.e., the biology of the living tobacco plant, is urgently needed. These changes, and more importantly, how they might be manipulated must be understood. The knowledge gained from a study of these biological changes could lead to more efficient production while maintaining a highly desirable product that will assure the enjoyment of millions of consumers.

United States tobacco has been the criterion of quality sought by manufacturers and emulated by growers throughout the world. Superior flavor, aroma, and well-balanced physical and chemical components in flue-cured tobacco, the principal export type, have contributed largely to this reputation. However, the necessity to replace previously well-established varieties with new ones possessing resistance to several major diseases, as well as certain modifications in cultural practices, have been alleged to alter market acceptability. Fortunately, recent research, including the development of new varieties, has had a significantly favorable impact on quality improvement.

2. Cigarette Types

Flue-cured and burley are the major cigarette types comprising approximately 50 and 40 percent, respectively, of the domestic leaf used in the average cigarette blend. In addition, flue-cured and burley account for 75 percent and 7 percent, respectively, of leaf exports. Maryland type makes up less than 2 percent of the average domestic blend and usually accounts for about 2 percent of total tobacco exports. It is important in exports to certain European countries, notably Switzerland, where major cigarette blends are made entirely of Maryland leaf.

An important part of tobacco quality is the health-related aspect of smoking. During the 8 years prior to issuance of the Smoking and Health Report in January 1964, U. S. consumption of cigarettes increased 3.7 percent per year. Following the Report, 1964 consumption of cigarettes dropped 2.4 percent below the peak reached in 1963. However, the downtrend reversed and the 1963 peak was surpassed in 1965. More recently, the annual rate of increase in cigarette consumption averaged only about 1 percent per year. Currently available breeding techniques and germ plasm have shown the possibility of producing varieties with varying levels of nicotine, phenols, and sterols. Smoke chemistry has progressed

to the point where more than a thousand compounds have been identified and a few of them related to flavor and aroma of the smoke. As their role either in flavor or aroma or health of the consumer can be determined, opportunity is provided to modify constituents of the leaf or smoke in a favorable direction.

3. Cigar Types

A large segment of the U. S. cigar industry was based on the use of Cuban cigar filler tobacco, which is not produced anywhere in this country. Early in 1962, the U. S. embargoed imports of Cuban tobacco and since that time domestic stocks of this tobacco have been extended by combining them with cigar filler from other sources.

Stocks of Cuban cigar filler still remaining are relatively very small and nearing depletion. The cigar industry and Tobacco Advisory Committee have requested repeatedly that research be initiated to develop suitable substitutes for Cuban cigar filler. Resources available, however, have limited research to exploratory investigations.

Production hazards such as weather fleck, diseases, and insects plague cigar wrapper tobacco producers. On an acre basis, this type tobacco is one of the most valuable crops in the U. S., yet its relatively small acreage has attracted comparatively less research support than the major tobacco types. Processed binders have become so widely accepted, the acreage of binder type tobacco has decreased to about 10 percent of that formerly grown.

4. Other Types

Dark air-, fire-, and sun-cured tobaccos are grown in certain areas of Kentucky, Tennessee, and Virginia, but during recent years, farmers have planted less than half the acreage they formerly grew. Grower prices are considerably below those of flue-cured, burley, and Maryland tobaccos yet fire- and dark air-cured growers have production costs per acre almost as great. Fire-cured tobacco has no substitute and export buyers have expressed concern about future leaf supplies for specialized markets in Europe and Africa. Improved production efficiency and quality would increase returns to growers of these tobaccos.

5. Non-Chemical Pest Control

Chemical methods of pest control are used widely in the control of suckers, insects, and nematode diseases. Without them, tobacco yields would fluctuate and probably decrease, yet growers, manufacturers, and exporters are increasingly interested in attempts to grow

tobacco without chemical residues. At the same time, public opposition to the general use of pesticides continues to increase. Sentiment against chemical residues is even greater in countries that buy U. S. tobacco than in the U. S. itself. For example, by 1973 Germany will apply, under present proposals, the same chemical residue tolerances on tobacco as on food crops. The 1973 tolerance level will be about 10 percent of that for agricultural chemicals on raw food products in the United States. If other European countries follow Germany's action, U. S. tobacco grown under present production practices would not be acceptable to these important markets.

In recent years, about a third of the tobacco crop has been exported. European countries take about 70 percent of U. S. tobacco exports. Thus, to use or not to use pesticides looms large in the economic situation of the tobacco producer.

Much of the basic research of biological and physical methods of insect control is in progress. In addition, breeding for resistance to insects of tobacco is in its exploratory phase. Very successful programs in breeding for resistance to disease and nematodes over a 30-year period have shown the value of resistant germ plasm in pest control. Initial results in breeding for resistance to tobacco insects suggest these efforts may emulate the older programs in resistance to tobacco diseases.

At present, the use of chemicals for sucker control and the control of some pests is necessary to produce a crop. Increased attention must be given to insure that chemicals used or their metabolic and combustion products do not impair quality and are not potentially hazardous.

6. Production Efficiency

Efficiency in tobacco production has not kept pace with that in other major crops. This is illustrated by the average labor requirements compiled by the USDA Economic Research Service.

Period	Corn	Wheat	Soybeans	Cotton	Tobacco
		Man-Hours Per Acre			
1910-14	34.2	15.2	15.9 1/	116.0	365.0
1962-66	6.2	2.9	4.8	40.0	496.0

1/ Average 1925-29

Yields per acre increased 2 to 2½ times on all crops during the period covered. However, the heavy labor requirement for tobacco puts tobacco growing at a competitive disadvantage at a time when labor costs are rising rapidly and farm labor supply is declining.

The changing labor situation makes it advantageous to growers to adopt labor saving production and marketing practices. Also, marketing regulations have been revised to permit sale of loose leaf instead of the traditional hand-tied bundles.

In the mechanization of most crops, adapted varieties have had an important role. Most likely this will be true for tobacco. As a start in that direction, breeding stocks are available which double efficiency of proto-type harvesting machines. In addition, procedures are being developed to automate curing and mechanize handling of leaf at the auction sale.

The U. S. tobacco crop, with high production and marketing costs, smoking and health problems and declining competitiveness in the world market, is in an unique position to show excellent returns for research inputs. Potential benefits are difficult to estimate because of the many variables involved in maintaining economic production of a high quality product and barriers to the free movement of U. S. tobacco in world trade. However, even modest progress toward attaining the objectives outlined in this report will pay high dividends to the tobacco producers and consumers.

JOINT TASK FORCE ON TOBACCO RESEARCH

Summary of Inventory and Recommended SMY's with Adjustments Proposed by the Task Force

Research Problem Area	1966 Base 1/			1972 2/						1977 2/					
	TOTAL	USDA	SAES	TOTAL		USDA		SAES		TOTAL		USDA		SAES	
				JC	TF	JC	TF	JC	TF	JC	TF	JC	TF	JC	TF
Control of															
207 Insects	19	9	10	24	31	11	18	13	13	29	34	14	18	15	16
208 Diseases	32	9	23	40	42	11	13	29	29	48	50	13	15	35	35
209 Weeds	2	0	2	4	6	0	0	4	6	5	6	0	0	5	6
TOTAL - Protection	53	18	35	68	79	22	31	46	48	82	90	27	33	55	57
Biological															
307 Efficiency	51 3/	19	32	53	58	19	24	34	34	57	61	20	26	37	35
308 Mechanization	15 4/	2	13	15	24	2	6	13	18	17	25	4	6	13	19
309 Systems	1	0	1	1	4	0	1	1	3	3	6	1	2	2	4
405 Consumer acceptability	22	15	7	31	39	22	25	9	14	44	44	32	29	12	15
TOTAL - Production	89	36	53	100	125	43	56	57	69	121	136	57	63	64	73
New & Improved															
407 Non-Food	24	16	8	27	45	18	27	9	18	35	45	23	27	12	18
408 Quality Maint. in marketing	3	2	1	4	6	3	5	1	1	5	7	4	6	1	1
TOTAL - Development	27	18	9	31	51	21	32	10	19	40	52	27	33	13	19
501 Grades & Standards	0	0	0	-	3	-	2	-	1	-	3	-	2	-	1
504 Efficiency in marketing	2	1	1	2	5	1	3	1	2	5	7	2	4	3	3
TOTAL - Marketing	2	1	1	2	8	1	5	1	3	5	10	2	6	3	4
Grand Total:	171	73	98	201	263	87	124	114	139	248	288	113	135	135	153

1/ Inventory of Agri. Res., Volume I, Table I, June 1967. Adjustments were made in RPA's 307 and 308.
2/ A joint committee representing the Experiment Station Committee on Organization and Policy and the USDA met July 1967 to review manpower allocations and recommend the SMY's shown in columns headed "JC."
3/ Base increased from 40 to record 11 SMY's not accounted for in original base figures.
4/ Base increased from 8 to record an additional 7 SMY's reported by States.

II RESEARCH PROBLEM AREAS

TITLE: Biological and physical methods of controlling tobacco insects. RPA 207-A

SITUATION: Many insect species that attack tobacco are resistant to insecticides that formerly gave effective control. This phenomenon and public concern about potential hazards to human health and wildlife from insecticide residues on tobacco and pollution of the air, soil, and water creates an urgent need for further development of non-chemical methods for control of insects. Considerable progress has been made in the basic development work on biological and physical methods of insect control. However, large scale experiments are required to demonstrate their effectiveness in the control of tobacco insects both in the field and on stored leaf.

OBJECTIVE: Develop insect control methods to minimize or avoid the use of insecticides at costs competitive with present control methods.

RESEARCH APPROACHES:

A. Develop tobacco varieties resistant to insects.

B. Develop biological control methods for use in the field and storage warehouses, including use of parasites, predators, and pathogens.

C. Develop cultural practices to suppress insect populations.

D. Evaluate insect behavioral responses to various attractants such as radiant energy, sex attractants, and plant components, and determine feasibility of using these methods of control.

E. Evaluate the effectiveness of sterile-insect releases over large areas to control specific tobacco insects.

F. Develop integrated programs to control tobacco field and storage insects combining genetic, cultural, biological, physical, and where necessary, chemical methods.

G. Correlate this research with that in RPA's 208, 405, 407, and 408.

CHARACTER OF POTENTIAL BENEFITS: Reduce the cost of controlling insects and eliminate or reduce pollution of tobacco and the environment with insecticides.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
12	14

TITLE: Insecticidal methods of controlling tobacco insects.
RPA 207-B

SITUATION: Insecticides are necessary at present to control insects that attack tobacco. However, there is growing public concern over some undesirable features and effects involved with current insecticide usage. Some insects have become resistant to certain compounds; thus, a continual need for both old and new insecticides to control infestations and sudden outbreaks of insects will exist.

There are no tolerance limits for insecticide residues on tobacco in the United States. However, this situation may change because foreign countries may not continue to accept tobacco containing certain chemical residues. Present application techniques fail to distribute insecticides uniformly; thus average dosages are high in order to achieve effective levels on all parts of tobacco plants.

OBJECTIVE: Develop cheaper, more effective methods of insecticidal control that will not leave undesirable residues, harm beneficial insects, or be hazardous to man and animals.

RESEARCH APPROACHES:

A. Search for nonpersistent insecticides that are safer and more selective.

B. Develop improved methods of applying insecticides.

C. Study the mechanisms by which insects become resistant to insecticides.

D. Evaluate the effect of present and new insecticides on beneficial insects and wildlife.

E. Study the climatological, mechanical, and physiological factors in phytotoxicity of insecticides applied to tobacco.

CHARACTER OF POTENTIAL BENEFITS: More effective control of insects at lower cost and reduced residue and pollution problems.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
10	11

TITLE: Ecology of insects attacking tobacco. RPA 207-C

SITUATION: Tobacco is subject to attacks by numerous insects including aphids, flea beetles, hornworms, budworms, loopers, and wireworms. Research on various approaches for control of these insects indicates the potential of suppressing populations in large areas with limited or no use of insecticides. If these new approaches are to be successfully applied, it will be necessary to develop methods to detect insect populations and to estimate their abundance in a given area.

OBJECTIVE: Develop methods to obtain ecological data for area-wide control or suppression of tobacco insects by means of the sterile release technique, sex attractants, and light traps.

RESEARCH APPROACHES:

A. Determine the seasonal habits, preference for alternate host plants, and population dynamics of major tobacco insects; and from this information establish life tables for ecological areas.

B. Develop new and more effective equipment such as light and sex attractant traps for detecting insect populations.

C. Determine effects of weather upon life cycle and activity of insects including diapausing stages.

CHARACTER OF POTENTIAL BENEFITS: Reduced cost of production by more efficient methods of insect control. Tobacco yield will be increased with less insect damage to harvested leaves, residues that cause off-flavor will be reduced, and hazardous pesticide residue in the environment will be eliminated. Total population suppression in an area will also be beneficial in the culture of other crops.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
9	9

TITLE: Control of diseases through genetics and breeding. RPA 208-A

SITUATION: Resistant varieties are by far the most effective and widely used method of tobacco disease control. Only through their use is intensive tobacco production economically feasible. Resistance for most diseases, however, is not complete; and there are some diseases especially those attacking the leaf for which resistant varieties have not been developed. Therefore, diseases continue to exact a heavy toll from growers' profits. Losses caused by fungi, bacteria, viruses and nematodes total an estimated 14% of the crop on an annual basis. Further reduction in disease losses can be accomplished through additional efforts in breeding programs. Past experience has demonstrated the rewards are many times the costs involved in breeding research.

Better sources of disease resistance are needed. Very high resistance or near immunity to a few diseases, such as black root rot, wildfire, and mosaic has been transferred into cultivated tobacco from other Nicotiana species or wild relatives of tobacco. An equally high level of resistance to the root knot nematode has been developed through special procedures. Efforts to employ mosaic resistance in the control of this virus disease without impairment of quality has been successful in burley and cigar tobacco, but not in flue-cured. Considering all possible methods, however, the potential for improving disease control through the use of disease resistance is outstanding.

Damage to tobacco caused by air pollutants is assuming great economic importance. Air pollution damage is a major problem in the Connecticut Valley cigar producing area. While some varieties are more tolerant than others to industrial air pollution, no high level of resistance is available.

Poor stands and stunted plants caused by disease infection lead to irregular plant growth. Uniformity of growth and maturity are important in machine culture. Thus, improved disease resistance and better disease control are means of reducing production costs, and assuring the economic production of quality leaf to meet market demands.

OBJECTIVE: Control tobacco diseases through improved resistance and circumvent the use of chemicals which leave residues that may be deleterious to quality or potentially harmful to the consumer.

RESEARCH APPROACHES:

A. Search for germ plasm within Nicotiana tabacum to improve disease resistance including resistance to parasitic nematodes.

B. Screen other Nicotiana species for better sources of resistance.

C. Develop tobacco varieties of all types adapted to specified areas with combined resistance to pathogens prevalent in those areas.

D. Locate sources of resistance to toxic substances in the air and develop varieties resistant to air pollution.

E. Study physiological response of different sources of germ plasm to air pollutants.

F. Emphasize the development of resistance to tobacco pathogens, including viruses, bacteria and fungi.

G. Develop techniques and methods of estimating levels of disease resistance and disease losses.

H. Coordinate research on a regional basis taking into account RPA's 307 and 405.

CHARACTER OF POTENTIAL BENEFITS: Higher income through a substantial reduction of disease losses, more effective plant growth which will facilitate mechanical culture, reduction or elimination of potentially undesirable chemical residues and metabolic products which may be hazardous to the consumer.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
12	14

TITLE: Crop management practices to control tobacco diseases. RPA 208-B

SITUATION: Continuous tobacco culture increases the incidence of serious root diseases. Crop rotations aid in control of these diseases. However, rotations with certain crops may increase the incidence of the diseases. Also some weed species are hosts of tobacco pathogens including fungi, bacteria and nematodes. Rotations utilizing non-host crops are a standard recommendation for use with resistant varieties to control diseases. In addition, tillage methods that uproot stalks following harvest and otherwise destroy crop residue are important in controlling root diseases.

Chemicals are used to control the seedling disease, blue mold, and some root diseases caused by nematodes. Control of the leaf disease brown spot with fungicides is being investigated. Recent information shows chemicals may be used to enhance performance of resistant varieties in the presence of soil-borne pathogens. However, there is a growing concern about the potential effects of chemical residues on quality and consumer safety. It is anticipated that by 1973, Germany will impose stringent limits on chemical residues in tobacco that will restrict them to about one-tenth the level allowed on food products in the U. S. Satisfactory use of chemicals to supplement disease resistance in disease control depends upon the discovery of fungicides and nematocides that leave no harmful residues or metabolic products in the cured leaf.

OBJECTIVE: To study tobacco diseases under different cropping systems and chemical treatments in combination with resistant varieties for the purpose of improving disease control.

RESEARCH APPROACHES:

A. Study the effect of different pathogens on resistant and susceptible varieties under field conditions.

B. Study the effect of certain cropping sequences on disease development.

C. Study the effect of certain chemical treatments on the development of diseases.

D. Study the combination of crop rotations and chemical treatments on susceptible and resistant varieties.

E. Develop chemical disease control methods that leave little or no residues.

F. Search for more effective and safer pesticides and non-chemical methods of controlling nematodes, fungi, and other agents that cause diseases.

G. Develop application techniques and methods to improve pesticide performance.

H. Develop integrated methods of controlling diseases.

I. Coordinate with RPA's 207 and 308.

CHARACTER OF POTENTIAL BENEFITS: Higher income through substantial reduction of disease losses and circumvention of chemical residues which may be hazardous to the consumer.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
5	6

TITLE: Tobacco disease interactions and the nature of diseases. RPA 208-C

SITUATION: More than one pathogen frequently attacks tobacco, producing combined symptoms of greater severity than either organism would cause alone. These disease interactions are important in that they reduce resistance of the variety to the several diseases. An understanding of the biochemical nature of pathogenesis would be an aid in the development of better disease control measures. Furthermore, certain metabolites produced by disease organisms may have an adverse affect on quality of cured leaf or health of the consumer.

OBJECTIVE: Plan and conduct investigations with tobacco plants infected with various pathogens singly and in combination to provide information regarding the chemical and physical effects of these pathogens on the plant and determine the nature and levels of any metabolic products which may be important to smoking and health problems.

RESEARCH APPROACHES:

A. Expose tobacco plants to combinations of plant parasitic nematodes and pathogenic fungi, bacteria, and viruses to determine the presence of disease interaction by histologic and chemical means.

B. Critical histopathological studies of infection sites.

C. Critical chemical studies made of diseased and surrounding tissues.

D. Identify metabolites and study their influence on the diseases and estimate their potential effect upon quality of the product and health of the consumer.

CHARACTER OF POTENTIAL BENEFITS: The benefits from this activity are related directly to those from breeding and management. The information obtained will facilitate progress in other activities.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
5	7

TITLE: Methods of detecting and estimating populations of microorganisms harmful to tobacco. RPA 208-D

SITUATION: Information concerning the presence or absence of plant pathogens, levels of infestation, distribution of diseases, etc., are vital factors that must enter into the overall management decisions of tobacco producers and others in advisory or management services. For example, to select a disease resistant variety or to decide whether to fumigate for the control of soil borne pathogens, tobacco growers must rely on experience and informal advice. Insufficient research results are available to guide growers in making proper management decisions on disease prevention and control. Fundamental studies designed to develop methods and techniques for detecting and estimating populations of pathogens should be accelerated. Some of this work is already in progress on assaying for plant parasitic nematodes and advising growers about their control. This should be expanded and extended to other diseases. If reliable methods could be devised, especially for the major diseases of each tobacco type, a great reduction in human effort and cost could be realized.

OBJECTIVE: Develop methods and techniques for detecting, enumerating, identifying and evaluating pathogenic potential of microorganisms. Also, gain knowledge about these organisms and their role in pathogenesis, decays and potential effects on consumer.

RESEARCH APPROACHES:

A. Develop methods of detecting and enumerating plant pathogens and other harmful microorganisms on tobacco in the field and during the curing process.

B. Develop rapid methods of identifying these microorganisms.

C. Develop methods of determining and evaluating the pathogenic potential and harmful effects of these agents.

CHARACTER OF POTENTIAL BENEFITS: The benefits from this work are related directly to disease prevention or control. Knowledge obtained in this area would be of great value to crop management.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATIONS	
1972	1977
5	6

TITLE: Microbiology and ecology of soil-borne pathogens. RPA 208-E

SITUATION: Pathogens that cause such destructive diseases as black shank, Granville wilt, Fusarium wilt, black root rot, root knot and others are soil-borne. Thus the soil acts as a reservior for many pathogenic agents. These diseases are very troublesome and can cause devastating losses to growers. Resistant varieties have been developed, yet moderate to heavy losses still occur in some areas of intensive production.

Influence of the soil and the soil environment on the pathogens and disease development are not well understood even for such an important disease as black shank. For example, this disease has occurred on cigar wrapper tobacco in northern Florida and southern Georgia more than 40 years, longer than anywhere else in the United States. It has spread only to a limited extent into adjacent flue-cured growing areas. The natural factors are unknown which restricted spread of the disease from cigar tobacco into nearby flue-cured tobacco while it devastated flue-cured tobacco in distant growing areas. Their discovery would be helpful in the development of more effective disease control measures for all types of tobacco.

OBJECTIVE: Gain a better understanding of soil environment influence on soil-borne pathogens.

RESEARCH APPROACHES:

A. Investigate and identify the biological factors that influence specific pathogens and disease development including interrelationships.

B. Investigate and identify the physical and chemical factors in the soil that influence pathogens and disease development.

C. Study root exudates in relation to infection.

D. Study the influence of soil amendments, herbicides, and other materials on the pathogen and the disease.

E. Investigate the survival and reproduction in the soil of tobacco pathogens.

CHARACTER OF POTENTIAL BENEFITS: The benefits from this area of investigation is related directly to disease control. Knowledge gained would be beneficial to such research as breeding for disease resistance, disease interactions and chemical control.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
6	8

TITLE: Etiology and epidemiology of tobacco diseases. RPA 208-F

SITUATION: Numerous pathogens attack tobacco, yet much remains to be learned about specific pathogens and diseases. The life cycles, physiology and variability of pathogenicity are not well understood even for the tobacco pathogens that cause such diseases as black shank and brown spot. Also information on the influence of the environment on diseases and pathogens is lacking in many cases. Such information could be very helpful in the prediction of epidemics and when chemical control measures must be applied. Yield and quality reduction may range from slight to complete destruction and some losses are not easily determined because of their general nature. Estimated losses from brown spot in North Carolina alone have exceeded $4,000,000 annually for the past six years. However, very little is known about the genetics, physiology and pathogenicity of the brown spot fungus. Such basic information on the biology of important pathogens would be of great value in developing control measures.

OBJECTIVE: A more thorough understanding of the biology of pathogens and diseases including the influence of environmental factors on infection and disease development.

RESEARCH APPROACHES:

A. Study genetics and the influence of the environment on variability of pathogens.

B. Study the physiology of the pathogens.

C. Critical studies of life cycles of pathogens including mode of survival.

D. Develop effective inoculation techniques to facilitate investigation of damage and control methods for specific diseases.

E. Investigate vectors and carriers of pathogens.

CHARACTER OF POTENTIAL BENEFITS: The benefits from this work are related directly to those for breeding and management. The information obtained would greatly facilitate progress in other disease research and may lead to new methods of disease control.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
9	9

TITLE: Compatibility, methods of application and residual effects of multi-purpose pesticides, and fertilizers on tobacco. RPA 209-A

SITUATION: Tobacco farmers continually request research information that can be used to improve production efficiency by reducing labor requirements and production costs. Successful tobacco production usually necessitates treating the soil prior to sowing the seed bed and field transplanting with a nematicide, and insecticide, a soil fumigant, and an inorganic fertilizer. Currently each material is applied separately. The application of herbicides adds to the cost and complexity of soil treatments. In order to increase net returns research is needed to evaluate the effects of the simultaneous application of soil treatment materials on numerous pests, the growth of the crop, and its acceptance by the trade.

OBJECTIVE: To determine the acceptability of the simultaneous application of multiple pesticides and inorganic fertilizer materials with regard to compatibility, methods of application, and fate of the chemicals.

RESEARCH APPROACHES:

A. Evaluate the compatibility of various formulations of pesticides with respect to their action on specific pests as well as their effect on the host plant.

B. Develop methods of application which may have practical acceptance under farm conditions.

C. Analyze soil and plant materials to determine the presence of pesticide residues under different environmental conditions.

D. Determine toxicity of derivative residues.

E. Coordinate with research in RPA's 207, 208, 307, 308, and 405.

CHARACTER OF POTENTIAL BENEFITS: Increase tobacco production efficiency through the simultaneous application of multi-purpose pesticides and fertilizers. This reduction in labor requirements would be extremely important in helping U. S. tobacco compete in world markets.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
2	2

TITLE: Principles and practices to control specific weeds in tobacco. RPA 209-B

SITUATION: The weed flora in tobacco plant beds and fields vary from area to area, and from farm to farm. A satisfactory weed control program for one tobacco grower may not be suitable for another because of different weed species, different soils, different crop rotations, and different equipment availability. Many promising herbicides have a limited future use in tobacco production because suitable application techniques as well as equipment are lacking or impractical. More effective weed control could be achieved with better information on the control of specific weeds and suitable application techniques as they are affected by cropping sequences, cultural practices, and crop-soil-chemical interactions.

OBJECTIVE: To determine the most efficient and acceptable system of cultural, biological, and chemical control practices for specific weeds in tobacco.

RESEARCH APPROACHES:

A. Study the extent of yield losses due to weeds under present methods of control.

B. Study cropping sequences to determine the effect of cultural practices on weed populations.

C. Develop combinations of cropping sequence, herbicides, and cultural practices for specific weed situations.

D. Determine the most effective means of applying volatile and non-volatile weed control chemicals.

E. Develop application techniques for non-selective chemicals in tobacco, to include evaluation of preplant treatments and various directional devices to maximize weed control and minimize injury, taking into account position of the herbicide in the soil and uptake by the plant.

F. Coordinate with research in RPA's 307, 308, 405, and 407.

CHARACTER OF POTENTIAL BENEFITS: Increased tobacco yields by reduced weed competition. Make available to the tobacco grower basic information needed to select the best weed control system for his particular conditions. Reduced cost of production and increased net returns through decreased labor inputs.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
2	2

TITLE: Persistence of weed species common in tobacco fields. RPA 209-C

SITUATION: There has been very little study of the physiology, anatomy, and morphology of most weed species common in tobacco plant beds and fields. An in-depth study of the life cycle of annual and perennial weeds may reveal stages of growth at which chemical or cultural control would be most effective. The ultimate weed control practice is one which would lead to the destruction of weed seeds in the soil. An understanding of weed seed dormancy and methods of breaking dormancy could result in the development of better control practices. In addition, research is needed to determine the inherent resistance of both annual and perennial weeds to herbicides. As grower use of herbicides increases and cultivation decreases, resistant weed species will present a more serious problem.

OBJECTIVE: Determine stages in the life cycles of annual and perennial weeds where control measures would be most effective.

RESEARCH APPROACHES:

A. Determine growth patterns and relative competitiveness of weeds in relation to tobacco.

B. Determine physiological and anatomical characteristics of specific weeds and evaluate these characteristics as means of controlling growth.

C. Study the nature and extent of weed seed dormancy in various species and develop methods to alter dormancy. Emphasize time and extent of germination in relation to soil temperatures.

CHARACTER OF POTENTIAL BENEFITS: Better timing of cultural weed practices or chemical treatments; more effective use of weed control measures through an understanding of dormancy of weed seeds.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
1	1

TITLE: Herbicide specificity and mechanism of action on tobacco. RPA 209-D

SITUATION: Little is known concerning the mechanism of action of herbicides on the tobacco plant. During the past 15 years a large number of chemicals has become available for weed control. Many of these have not been critically evaluated for minimum levels of toxicity to individual weed species or to tobacco. Tobacco plants are extremely sensitive to many herbicides and thus plant injury may result from their use. Many herbicides are used without adequate information on specificity of the herbicide. A better understanding of the mechanism of herbicide action would facilitate the development of more acceptable materials.

OBJECTIVE: Determine the mode of action, minimum effective and toxic levels of herbicides, and develop materials more acceptable for efficient weed control.

RESEARCH APPROACHES:

A. Determine the minimum rate of specific herbicides needed to kill individual weeds in tobacco.

B. Determine the effects of herbicides on various metobolic systems in weeds and tobacco plants.

C. Develop and test theories, based on the results of objective B to explain herbicide specificity, selectivity and mechanism of action.

D. Use information from objectives B, C and D to design and search for new and more effective weed control compounds.

CHARACTER OF POTENTIAL BENEFITS: Formulation of safer and more effective tobacco herbicides for both the plant bed and the field. A satisfactory post-emergence chemical could eliminate weed control failures due to weather and reduce cost of weed control. The absence of weeds in tobacco fields is essential for mechanical harvesting of the leaf.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
1	1

TITLE: Transplant characteristics and plant uniformity. RPA 307-A

SITUATION: Seedling production on farms is not geared to the production of plants individually sized for use in completely mechanized transplanting. New transplant production procedures are required to achieve uniformity of seedling growth and which will permit mechanical handling of single plants. Uniformity of plant growth must start with the germination of the seed and every operation which follows must be undertaken with this consideration in mind. Machines for transplanting tobacco seedlings are in advanced stages of development. To effectively utilize these advancements, means must be found to produce uniform seedlings for transplanting without the need for hand labor.

OBJECTIVE: Develop efficient methods of producing uniform seedlings and to identify management practices which will result in more uniform stands.

RESEARCH APPROACHES:

A. Evaluate plant growth media and production systems to facilitate machine transplanting.

B. Evaluate tobacco seed germination processes with the ultimate goal of sowing individual seeds so that a high percentage of healthy, uniform plants will be produced.

C. Evaluate management practices, such as the effects of supplemental light, temperature, water, disease control, etc., as they relate to uniformity of seedling growth.

D. Coordinate with weed studies in RPA's 209 and 308.

CHARACTER OF POTENTIAL BENEFITS: Uniform plants will enable mechanization to be more fully realized.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
5	5

TITLE: Breeding for quality and efficiency in tobacco production.
RPA 307-B

SITUATION: Efficiency in tobacco production has not kept pace with that in other major crops. The average labor requirements for all types of tobacco has increased from 356 man hours per year in 1914 to 496 in 1966. Therefore, mechanization is essential for the continued economic production of the crop. In the mechanization of most crops, adapted varieties have had an important role. Most likely this will be true for tobacco. Breeding stocks are available which double efficiency of prototype harvesting machines and which produce acceptable quality leaf. Even so, quality improvement has lagged behind increases in yields. The development of varieties adapted to mechanical, cultural and curing practices, and means to bring quality improvement, including health factors in line, are urgently needed.

OBJECTIVE: Develop and improve varieties and breeding lines of all tobacco types that will produce high-quality leaf with greater efficiency.

RESEARCH APPROACHES:

A. Search for germ plasm within Nicotiana tabacum to improve yield and quality of all tobacco types.

B. Develop more effective methods for interspecific transfer of useful germ plasm.

C. Introduce characters for varietial improvement from Nicotaina species into all tobacco types.

D. Develop varieties of primed and stalk cut tobacco adapted to machine harvest that produce acceptable yields of leaf which meet market requirements.

E. Breed varieties that mature, ripen and cure uniformly.

F. Give special attention to the breeding and genetics of varieties that survive natural and environmental production hazards.

G. Develop varieites with increased photosynthetic activity and more efficient root systems.

H. Study the genetics of lateral bud formation and select for reduced sucker growth.

I. Conduct comprehensive studies on genetic control of physical and chemical quality components in order to enhance those which are desirable and reduce or eliminate those which are undesirable or potentially harmful.

J. Investigate physical and biochemical changes in leaf during curing.

K. Coordinate efforts of plant breeders and agronomists in the development of production systems that permit efficient utilization of curing facilities.

L. Coordinate with RPA's 207, 208, 209, 308, 309, 405 and 407.

CHARACTER OF POTENTIAL BENEFITS: Decrease the high production costs, and improve the demand for U. S. tobacco in export markets.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
18	18

TITLE: Improved plant uniformity and growth. RPA 307-C

SITUATION: Modification of cultural practices from transplanting to harvesting is necessary to facilitate the use of machines in tobacco culture, harvesting and curing. The capstone upon which all else depends is uniform stands, uniform growth and uniform ripening. These must be accomplished before mechanical harvesting and curing will result in a raw product which consistently meets domestic and export trade requirements.

OBJECTIVE: Uniform growth, maturity, and ripening of tobacco plants for efficient mechanized culture, harvesting, and improved quality.

RESEARCH APPROACHES:

A. Relate plant growth and development processes such as respiration, enzymatic action, carbohydrate, lipid, and amino acid metabolism to production efficiency, leaf ripening, curability, and quality.

B. Develop new cropping and production systems which enhance uniform growth and development of the plant.

C. Examine the interaction among such variables as soil properties, irrigation, nutritional requirements, varieties, plant spacing, curing methods, sucker control and topping procedures for the improvement of plant uniformity, production efficiency and quality of cured leaf.

D. Coordinate with RPA's 209, 308, 405, and 407.

CHARACTER OF POTENTIAL BENEFITS: More efficient production of cured leaf through improved cultural methods which complement production machinery.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
13	13

TITLE: Growth regulators for tobacco. RPA 307-D

SITUATION: Growth regulating chemicals are now used for the control of sucker growth on tobacco plants. Effective sucker control is mandatory for the development of mechanized production systems to reduce labor requirements. Chemicals which top and sucker tobacco in one operation can be developed. New application techniques involving the use of foams have potential benefit. Chemical growth regulators influence certain chemical constituents of tobacco plants. Plant growth regulating chemicals also should be investigated from the standpoint of promoting uniform leaf maturity and ease with which leaf is cured. However, use of growth regulators must be evaluated carefully from the standpoint of their effects on quality or potential hazards to the consumer.

OBJECTIVE: Develop plant growth regulating chemicals to control sucker growth, the flowering process, leaf maturity, and modify the chemical and physical properties of the plant without impairing quality.

RESEARCH APPROACHES:

A. Screen chemicals to identify compounds which may be useful in controlling the growth of the tobacco plant.

B. Determine the role of surfactants, nature of leaf surfaces, the effect of environmental conditions, and physiological status of the plant on the effectiveness of foliar applications of growth regulators.

C. Conduct studies to determine the influence of plant growth regulators on production efficiency, leaf quality and usability.

D. Conduct basic metabolic studies to identify reactions or systems which might be modified with growth regulators.

E. Determine residue levels of plant growth regulators.

F. Coordinate with RPA 308, especially in regard to application techniques.

CHARACTER OF POTENTIAL BENEFITS: Maintain production efficiency without impairment of quality.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
10	12

TITLE: The biochemistry of tobacco ripening and curing. RPA 307-E

SITUATION: Ripening and curing involve the gradual controlled senescence of the leaf. Best cures depend upon harvesting leaf at optimum ripeness. During the curing process, many chemical, enzymatic and physical reactions and changes occur. An understanding of the biochemical and physical changes occuring in these systems will aid in devising improved curing regimes.

OBJECTIVE: Determine means of determining optimum stage of ripeness.

A. Devise means of determining optimum stage of ripeness.

B. Ascertain the biochemical and physical changes occuring under various curing systems.

C. Determine the optimum curing conditions to promote desirable physical and chemical changes.

D. Determine how and under what conditions these desirable changes can be made to occur and means to reduce or eliminate consitutents.

E. Coordinate with RPA's 308, 405 and 407.

CHARACTER OF POTENTIAL BENEFITS: Improved quality and usability of cured leaf.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
12	13

TITLE: Mechanization of tobacco seedling production and transplanting. RPA 308-A

SITUATION: Chemical weed control and semi-mechanical transplanters have reduced human energy requirements for growing and transplanting tobacco seedlings by 85%. Nevertheless, about 40 man hours per acre are required for seed bed preparation, pulling seedlings, and transplanting. Poor stands and uneven field growth often result from root damage in the conventional transplanting method. A mechanized system to automate the handling and transplanting of seedlings produced singly in individual containers would result in efficient establishment of uniform stands. Also mechanical means of seed bed thinning, pulling, sizing, and transplanting should be studied.

OBJECTIVE: Develop labor-saving devices and techniques for tobacco seedling production and field transplanting that would promote uniform stands.

RESEARCH APPROACHES:

A. Develop mechanical and automated devices for preparing soil or media for germination and growth of tobacco seedlings.

B. Develop mechanical and automated devices for placing seed in the substrate and for selection and thinning of seedlings.

C. Develop equipment to monitor the plant's environment and to maintain optimum conditions for growth.

D. Develop labor-saving mechanical and automated-transplanting systems.

E. Coordinate with RPA 208, 209, and 307.

CHARACTER OF POTENTIAL BENEFITS: Complete stands and uniform growth of tobacco plants.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
2	3

TITLE: Mechanical application of agricultural chemicals. RPA 308-B

SITUATION: Agricultural chemicals of all types are being used to a greater extent on tobacco. To be effective these chemicals must be applied to the proper parts of the plant or soil in the required concentrations at the right time. Machinery which is simple to operate and effective in all respects must be developed. Amounts of pesticides used could be drastically reduced and residues on the cured leaf could also be markedly lowered with more precise application equipment. In addition, the proper placement of fertilizers will facilitate the establishment of stands and promote even growth.

OBJECTIVE: To develop effective and efficient machinery for the application of agricultural chemicals to tobacco and reduce their metabolic products or residues on cured leaf.

RESEARCH APPROACHES:

A. Develop engineering principles for the improved application of all chemicals, including fertilizers, used on tobacco.

B. Develop labor-saving mechanical and automated equipment for precisely applying pesticides throughout the soil or on the plant.

C. Develop systems for applying chemicals that are not dependent on the weather.

D. Develop thermal, mechanical, and electrical systems for controlling tobacco pests.

E. Coordinate with research in RPA's 207, 208, 209, 307, 405, and 407.

CHARACTER OF POTENTIAL BENEFITS: Reduced use of pesticides and residue levels with more efficient application.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
2	2

TITLE: Conditioning soil for growing tobacco. RPA 308-C

SITUATION: Conditioning the soil for tobacco production includes burial of crop residues, breaking of clods, sub-soiling, fumigating, row bedding, applying fertilizers and herbicides, and irrigating as needed. In addition, new systems of culture, such as sod planting, may impose new soil preparation requirements. Proper soil conditioning is necessary for uniform growth and maturity, but soil conditioning is not optimum on much of the land planted to tobacco.

OBJECTIVE: To develop labor-saving machinery for providing a growing medium for tobacco.

RESEARCH APPROACHES:

A. Define in engineering terms minimum necessary soil requirements for producing vigorous growing, uniform maturing, usable, and desirable tobacco plants.

B. Develop economical and efficient equipment and techniques for proper soil conditioning.

C. Develop instrumentation for effectively determining plant requirements, soil condition, and machinery to impose needed soil condition modifications.

D. Coordinate with RPA's 207, 208, 209, 307, 405, and 407.

CHARACTER OF POTENTIAL BENEFITS: Contribute to precision in soil conditioning and efficient production practices for tobacco.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
2	2

TITLE: Mechanical harvesting of tobacco. RPA 308-D

SITUATION: Practically all tobacco is hand harvested and requires about 150 man hours per acre. Leaves of flue-cured and cigar wrapper types are removed individually, or primed, as they ripen. Harvesting all other tobacco types is, in general, by the stalk-cut method when most leaves on the plant are nearest optimum maturity. Scarcity of labor and rising wages make mechanical harvesting a major need of tobacco growers.

Many flue-cured tobacco growers use the taxi-type harvester. It permits the primers to ride and eliminates some of the harvest drudgery. Mechanical tobacco harvesters are being developed and farm tested, but these mechanical harvesters are relatively costly and do not position the leaves for further processing. About 40 acres of tobacco are required for maximum use of these harvesters. In addition, about 40 man hours per acre are required to align the leaves. A considerable portion of the harvester cost and design restriction is due to the requirement to remove intact only a few leaves from each stalk per week without damaging those remaining. A low profile, once-over, tractor-mounted harvester would provide inexpensive equipment and would be suitable for small farms. Preliminary tests with such harvesters have been encouraging. However, the interrelationships of varieties and cultural practices have not been evaluated which will permit the use of a once-over harvester, and at the same time, produce cured leaf acceptable to domestic and export markets.

In burley and Maryland tobacco types, field tests have been conducted with machines to harvest stalk-cut tobacco compatible with existing curing facilities. In addition, for burley, controls and power circuits for hydraulic and pneumatic harvester components have been designed to fasten the base of cut tobacco to continuous twine for incorporation into a housing system utilizing vertically suspended strings. Also, portable curing frames and fork-lifts are being investigated to aid in harvesting burley tobacco.

A leaf harvesting machine for cigar binder tobacco was developed. The decrease in demand for natural binder leaf, however, precluded its effective use. Mechanical harvesting of cigar wrapper tobacco presents special problems. The shade tent and plant support wires are obstacles to the unhampered movement of machines through the field.

OBJECTIVE: Develop mechanical harvesters.

RESEARCH APPROACHES:

A. Determine functional requirements for mechanical harvesting of tobacco under existing production practices.

B. Investigate production practices that would enhance the development of mechanical tobacco harvesters.

C. Develop mechanical harvesting systems suitable for large and small farms compatible with production systems to insure maintenance of cured leaf quality.

D. Investigate new concepts for harvesting tobacco such as once-over harvesting of flue-cured tobacco and culture of cigar wrapper tobacco without shading.

E. Develop systems for loading, transporting, and unloading large volumes of green tobacco.

F. Develop systems for holding green tobacco for extended periods.

G. Define green leaf properties related to bulk transporting and investigate possibility of curing in transporting unit.

H. Coordinate with RPA's 307, 309, 405, and 407.

CHARACTER OF POTENTIAL BENEFITS: Mechanization of tobacco harvesting through marriage of machine with revised production practices and specially adapted varieties.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
10	10

TITLE: Mechanization of green-leaf tobacco processing. RPA 308-E

SITUATION: Bulk curing and use of stitching machines for harvested flue-cured tobacco leaves to conventional sticks are available but have not been widely accepted. Most flue-cured tobacco is still cured in old-type barns requiring approximately 140 man hours per acre for stringing, placing in the barn and curing. Labor requirements are reduced about 25 to 50% by using the bulk racking innovation in conjunction with bulk curing facilities. Bulk racking is the only green-leaf processing operation presently compatible with the non-aligned leaves of mechanically harvested flue-cured tobacco. However, manufacturers are not equipped to handle this tangled leaf nor can it be assigned official U. S. Government grades. Bulk racks account for one-hourth to one-third the cost of bulk curing facilities. Positive air-flow design of bulk curing barns enhances the success of completely automatic curing control. Complete automation of the curing process requires an understanding of chemical and physical changes which take place in leaf. Such information would facilitate the development of schedules for automatic curing of different lots of ripe leaf.

In burley tobacco, the use of supplemental heat and forced ventilation would increase the capacity of conventional air-curing barns. Curing tests to determine the possibility of curing stalk-cut tobacco on vertically suspended strings during conventional air-curing have indicated that this method is satisfactory.

In the leaf processing of cigar wrapper tobacco, many steps in curing and fermentation process could be mechanized. Some private inventions are just now finding acceptance, such as the collapsible basket and shed conveyor system, to improve sewing efficiency.

OBJECTIVE: Develop labor-saving systems for processing green leaf.

RESEARCH APPROACHES:

A. Define requirements for green-leaf tobacco processing including ordering.

B. Catalog green-leaf properties related to curing and develop improved curing systems.

C. Develop instrumentation for monitoring leaf states and the curing environment, and means for adjusting processing conditions automatically to obtain optimum quality.

D. Exploit the forced-air bulk curing concept for developing economical curing equipment and alternates for use with tobacco packed in large volume transporting units.

E. Devise means for handling and preparing cured leaf for market.

F. Investigate and develop automatic curing equipment.

G. Develop requirements for tobacco production systems that permit more efficient utilization of curing facilities.

H. Develop systems for reducing the labor time required for aligning leaves.

I. Coordinate with RPA's 307, 309, 405, 407, 408, and 504.

CHARACTER OF POTENTIAL BENEFITS: The development of mechanized, economical and efficient processing facilities compatible with harvesting and transporting operations to enhance the early adoption of mechanical harvesting of tobacco.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
6	6

TITLE: Mechanical Handling of Cured Tobacco on the Farm. RPA 308-F

SITUATION: Approximately 135 man hours per acre are required for stripping, grading, and tying burley tobacco. Preliminary research indicates that removing cured tobacco in "frames" to a plastic enclosure for automatic casing is satisfactory for market preparation. This is an excellent example of flexible handling systems for pre- and post-harvest transportation of leaf.

Practically all flue-cured tobacco is removed from the curing barn and placed in short-term storage buildings. This requires approximately 14 man hours per acre. Sorting and tying leaf into bundles, requiring about 120 man hours, is rapidly being made obsolete by loose-leaf sales. Loose-leaf sales have had a tremendous impact on the marketing system by (1) reduction of farm labor, (2) congestion at auction markets, (3) higher labor or machinery requirements at cured-leaf processing plants, and (4) less on-the-farm grading. Presheeting on the farms of loose leaf shows promise of reducing some of the problems at the cured leaf processing plant. Improvements are being sought in means of selling loose leaf which will be satisfactory to producers and buyers.

OBJECTIVES: Determine labor-saving systems for handling on-the-farm leaf processing compatible with the auction market and cured leaf processing plants.

RESEARCH APPROACHES:

A. Design mechanical systems for handling cured leaf on the farm suited for integration with central grading, auction warehouses, and cured-leaf processing plants.

B. Design mechanized systems for short-term and long-term storage of tobacco that can be readily transferred to alternate packages.

C. Develop suitable packages for handling and selling loose-leaf tobacco.

D. Develop instrumentation for monitoring pertinent parameters of cured tobacco stored on farm with means for making necessary adjustments for safe tobacco storage.

E. Coordinate with RPA's 207, 309, 405, 407, and 504.

CHARACTER OF POTENTIAL BENEFITS: Mechanized and efficient handling of tobacco on the farm compatible with green-leaf processing and cured-leaf marketing facilities.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
2	2

TITLE: Systems analysis of mechanical processes in tobacco production. RPA 309-A

SITUATION: Tobacco production is currently in a transition phase from conventional to complete mechanical systems. Producers must choose among various "intermediate" systems. Each system is composed of different degrees of mechanization for successive plant bed, field, harvesting, and market preparation operations. The proper selection of a system should provide for optimum use of the producer's resources, i.e., land, labor, and capital management skills. This choice is influenced by such factors as (1) the amount of tobacco acreage available, (2) investment requirements of each system, (3) labor requirements for each operation and the wage rates, (4) mechanical proficiency of each system, (5) management skill of the operator, and (6) location of production. More precise capital budgeting models are needed to compare the profitability of these various systems. Also needed are more accurate data on labor and capital requirements for the successive plant bed through market preparation operations.

OBJECTIVE: Determine the mechanical and labor inputs that will maximize net farm income.

RESEARCH APPROACHES:

A. Identify and classify various subsystems and systems.

B. Use simulation methods, farm surveys, and controlled experiments to obtain data on labor and capital requirements for the relevant systems.

C. Analyze and compare the profitability of each system using depreciation-breakeven and other capital budgeting procedures.

D. Coordinate with RPA 308.

CHARACTER OF POTENTIAL BENEFITS: Reduced unit tobacco production costs and increased net returns to farm resources.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
2	3

TITLE: Systems analysis of biological processes in tobacco production. RPA 309-B

SITUATION: Tobacco producers must choose among many alternative systems when selecting varieties, plant bed chemicals, plant populations, nematocides, herbicides, insecticides, grades and amounts of fertilizer, irrigation, sucker control methods, curing and market preparation procedures. The proper selection of the various biological and chemical practices is largely, but not completely, independent of the mechanical system employed. More effective use of budgeting, programming, and simulation models is needed to compare the profitability of various alternative sets of practices.

OBJECTIVE: Determine the set of biological and chemical inputs that will maximize net farm income.

RESEARCH APPROACHES:

A. Identify and systematically classify various systems.

B. Use farm surveys and controlled experiments to obtain data upon costs and returns with various biological and chemical practices.

C. Analyze and compare the profitability of each system using budgeting, programming, and least-squares regression techniques.

D. Coordinate with RPA's 207, 208, 209, 307, and 405.

CHARACTER OF POTENTIAL BENEFITS: Reduced unit tobacco production costs and increased net returns to farm resources.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
1	2

TITLE: Application of operations research techniques to tobacco production. RPA 309-C

SITUATION: When considering production systems as complicated as those for tobacco, it is often difficult or impossible to determine beforehand which possible improvements will result in the greatest potential benefits to the grower and to the industry. Changes in cultural practices, varieties, mechanization, etc., all produce changes in machinery scheduling requirements, plant environment, capital and labor requirements, etc. It is possible to construct a theoretical framework which can be used to assess many possible changes without the necessity for extensive preliminary field experimentation, thus reducing the time and increasing the reliability for reducing a new production idea to practice. The field of operations research offers many possible techniques for developing the theoretical framework. Most promising at this time is the technique of simulation. A mathematical model of overall plant response is developed, and its reaction to the random variation typical of field conditions is verified. Then to this plant model are added the environmental constraints imposed by a given system of machines and practices. The response of the plant to these constraints is simulated many times mathematically to determine how good or bad it is for a given weather pattern. The use of high-speed computers (either digital or hybrid) makes it possible to perform such simulations quickly and easily. Other operations-research techniques that should be useful are mathematical programming (replacement and maintenance problems for machinery) and network analysis (machinery scheduling problems and transportation problems).

OBJECTIVE: To obtain better insight into economic and operational characteristics of tobacco production systems through development and analysis of mathematical models of the systems.

RESEARCH APPROACHES:

A. Develop a simulation model for tobacco plant response.

B. Identify and model typical existing and projected tobacco production systems.

C. Perform simulations to determine characteristics of each system.

D. Identify those features about each system which make it espectially bad or good (in terms of profitability and operational flexibility) and hypothesized improved systems.

E. Identify from the results of simulation new areas of basic investigation which will provide knowledge likely to result in immediate improvements in tobacco production systems.

F. Coordinate with RPA 308 and 309.

CHARACTER OF POTENTIAL BENEFITS: Better ability to control quality and costs and to adapt a production system to a given set of weather and crop conditions.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
1	1

TITLE: Improved consumer acceptability as related to market quality and potential hazard to the smoker. RPA 405-A

SITUATION: The influence of tobacco smoke upon the consumer from the standpoint of his pleasure and health is of major importance to the tobacco industry. Tobacco scientists are studying leaf composition and its relationship to smoke composition and potential effects on the consumer. The problem thus becomes (1) the understanding of the interrelationships of the genetics and physiology in constituent synthesis and the role of the pre- and post-harvest environment upon the final composition of tobacco, (2) the identification of leaf constituents that are precursors of important smoke components, and (3) the identification of smoke components that may affect the pleasure or health of the consumer. The magnitude and urgency associated with the solution of this problem require the cooperation of private, State, and Federal agencies.

OBJECTIVE: Identify parameters and biological control of selected leaf constituents and their relationships to a desirable smoke composition.

RESEARCH APPROACHES:

A. Identify physical and chemical properties of tobacco and elucidate the pathways of synthesis of important leaf constituents.

B. Measure the influence of growth, curing and storage environments on product quality.

C. Determine the best combination of varieties and cultural practices for optimum product quality.

D. Determine the genetic control of sucker initiation and development and pathways and utilize this information in breeding improved varieties.

E. Determine the influence of important smoke constituents on animal systems by appropriate bioassay techniques.

F. Coordinate with RPA's 207, 208, 209, 307, 308, 309, 407, 408, and 504.

CHARACTER OF POTENTIAL BENEFITS: The production of tobacco leaf with chemical and physical characteristics that yield the most desirable smoke.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
24	28

TITLE: Maintaining quality of mechanically produced and harvested tobacco. RPA 405-B

SITUATION: The increased cost and reduced availability of farm labor dictates emphasis on mechanization of production, harvesting, and curing procedures for tobacco, a crop long noted for its high labor requirements. Uniformity of growth and maturity will be required for mechanized handling of tobacco. Emphasis on uniformity and recognition that increased research inputs are necessary to insure that quality in mechanically handled tobacco will meet demands of the consumer.

OBJECTIVE: Develop tobacco varieties and cultural practices which result in greater efficiency of production and handling while providing a product acceptable to consumers.

RESEARCH APPROACHES

A. Develop varieties amenable to mechanical production, harvesting, and curing with special emphasis on uniformity of growth and maturation.

B. Develop cultural practices which provide optimum quality under conditions of mechanized production, harvesting, and curing.

C. Characterize tobacco from mechanized handling experiments in terms of present standards of quality and findings from health-oriented research.

D. Coordinate with RPA's 307, 308, 309, and 407.

CHARACTER OF POTENTIAL BENEFITS: Improvement in production efficiency to offset reduced availability and increased cost of labor with concomitant emphasis on quality to satisfy the consumer.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
15	16

TITLE: Development of improved cigarettes. RPA 407-A

SITUATION: A report, "The Health Consequences of Smoking," which summarized 3½ years of research was published in 1967 (Public Health Service Publication No. 1696). This report concluded that the 1964 findings of the Surgeon General's Advisory Committee on Smoking and Health had been confirmed and strengthened. It was indicated that shortened life expectancy and excess disability were attributable, in part, to cigarette smoking. The indicated health hazards have serious implications for tobacco growers, manufacturers, distributors, suppliers, exporters, and the consuming public. Since millions of people will continue to smoke, it is imperative that an improved cigarette be developed.

OBJECTIVE: To develop an improved cigarette by reduction of deleterious substances in cigarette smoke without sacrifice of flavor and aroma characteristics.

RESEARCH APPROACHES:

A. Isolate and identify constituents of tobacco and tobacco smoke that contribute to biological activity, flavor, and aroma.

B. Develop improved analytical methods for the determination of constituents of major biological and organoleptic importance.

C. Determine the chemical and biochemical changes which occur during fermentation and aging of tobacco.

D. Develop new and improved methods for the bioassay of tobacco leaf and smoke constituents.

E. Determine the biological activity of constituents of tobacco leaf and smoke.

F. Investigate the physico-chemical nature of the smoke-forming process, pyrolysis products of tobacco constituents and the influence of a combustion modifier on constituents in the vapor and particulate phase of smoke.

G. Devise methods for the selective reduction of specific compounds in tobacco smoke.

H. Coordinate with RPA 405.

CHARACTER OF POTENTIAL BENEFITS: The development of improved cigarettes would result in increased comsumption with attendant improvement in tobacco production, farm income, export trade, and consumer health. Federal, State, and municipal tax revenues would advance proportionately.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
41	41

TITLE: Increased flavor and aroma in cigars. RPA 407-B

SITUATION: Cigar consumption, which has trended downward since the unusually high peak of 1964, is expected to level out in 1968. Maximum consumption in 1964 was attributable to the Surgeon General's report which indicated a causal relationship between cigarette smoking and health but failed to implicate cigar smoking. In general, domestic consumption of cigars has not kept pace with population growth. Consumption would likely increase if cigars of improved flavor and aroma could be developed. Minimizing the strong after-odor of smoke and butts is an important part in the organoleptic betterment.

OBJECTIVE: To improve the flavor and aroma of cigar smoke and to minimize pungent after-odors.

RESEARCH APPROACHES:

A. Determine the constituents in cigar tobacco and smoke which are major factors in flavor and aroma.

B. Isolate and identify components in cigar smoke and butts which are responsible for undesirable after-odors.

C. Investigate the relative contributions of the filler, binder, and wrapper tobacco to organoleptic properties.

D. Develop methods, such as improved fermentation, filler blending, and flavor additives, for controlled alteration of flavor and aroma characteristics of cigar smoke.

E. Coordinate with RPA's 207, 208, 209, 307, and 405.

CHARACTER OF POTENTIAL BENEFITS: The development of cigars with pleasureful aroma and flavor will provide consumer satisfaction while avoiding the unpleasant effects of after-odors. These benefits should be a significant factor in a steady, well-founded growth of the cigar industry. The development of the cigar tobacco economy is of utmost importance to farmers, processors, distributors, consumers, and recipients of cigar tax revenues.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
4	4

TITLE: Quality maintenance of leaf tobacco in storage, during preparation for and while being marketed. RPA 408

SITUATION: Leaf tobacco is subject to decay, insect attack, and resultant deterioration while on the sales floor and in subsequent storage, processing, and marketing. When this occurs, an economic loss results, either to the producers or the purchaser. Information is needed as to the causes and prevention of this decay and deterioration. Rapid procedures are needed to detect the kinds and estimate the numbers of microflora which contaminate the leaf when it arrives at the auction floor. A study is needed to determine the requirements of auction facilities that will adequately protect the tobacco under varying weather conditions between the time it is delivered by the farmer, and the time of removal from the sales floor by the purchaser. Further study is also needed to develop improved methods for preventing insect infestation and damage to leaf tobacco and tobacco products during storage, manufacture, and transportation. Attention must be given to methods that will avoid undesirable chemical residues in the tobacco.

OBJECTIVE: To develop effective, safe, and economical procedures for preventing damage to tobacco and tobacco products in storage, during processing and in the market channels; also to determine the influence of contaminants and deterioration, sales floor environment, and duration of housing on tobacco delivered to the sales floor.

RESEARCH APPROACHES:

A. Identify the fungi and bacteria on different types of cured tobacco and determine those organisms most likely to cause decay.

B. Determine microflora population changes on tobacco during marketing.

C. Determine the effect of trash such as decaysed tobacco leaves, sand, earth and miscellaneous plant material that may be mixed with the tobacco when delivered to the sales floor, on the future spectrum and population of microflora and insects.

D. Develop standards in respect to the condition of the tobacco at the time it is delivered to the sales floor, and standards that the physical facilities of the sales floor should meet.

E. Determine if prolonged storage on the sales floor prior to the opening of markets is detrimental to the quality of the tobacco.

F. Study the biology, ecology, physiology, nutrition, and behavior of stored-tobacco insects as a basis for developing new or improved preventive and control measures.

G. Develop new or improved chemical, physical, biological, or environmental methods for preventing and controlling insect infestations in stored tobacco and tobacco products as well as for the facilities in which they are stored, handled, processed, and transported. Pay particular attention to chemical residues and ways of avoiding or minimizing them.

CHARACTER OF POTENTIAL BENEFITS: Improvement in quality and reduction in product loss during marketing, processing, and storage. The data obtained by research of this nature will also insure that the purchaser obtains a more firm product, and provide information for the farmer with respect to how he should prepare his product for sale.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
6	7

TITLE: Improvement of tobacco grades and standards. RPA 501

SITUATION: Well-defined standards and grades that accurately reflect the heterogeneity of natural products and the variations of user demands are indispensible for efficient marketing. Grades and standards in the marketing system should provide meaningful communication to all segments of the industry with respect to quality of a product in relation to its price. Objective, quick, accurate, and consistent measures for characteristics of economic significance are needed, along with increasing automation in the use of this information. Farmers are marketing more tobacco in loose leaf form and may have less interest in sorting into a large number of specifications. Traditionally, buyers have tried to inspect personally all lots of tobacco although most of it is sold rapidly at auction markets. The official United States Department of Agriculture standards provide for more than 100 grades for each tobacco type. These grades are determined by such factors as leaf position, color, and texture. However, individual buyers rely on a much smaller number of grades, including those developed by their respective companies. Newer knowledge of organic and smoke chemistry has not been incorporated in the grading system. Low cost, rapid and accurate methods of testing for new as well as established leaf characteristics at buying points are not now available.

OBJECTIVE: To provide grades and standards that will effectively communicate value differences for varying gradations of quality.

RESEARCH APPROACHES:

A. Evaluate the effectiveness of existing grade standards in serving the needs of buyers and sellers in describing different gradations of quality which affect value and use.

B. Determine the need for grade standards for new characteristics desired by buyers or consumers and those to be developed in the future based on smoking and health research and new processing technology.

C. Develop more objective measurement techniques for grade standards which will describe the different attributes of tobacco so as to facilitate communication between buyers and sellers.

D. Develop data on adjustments needed to reflect the revisions in grades and standards.

E. Coordinate with RPA's 405, 407, and 408.

CHARACTER OF POTENTIAL BENEFITS: Improved communication among farmers, buyers, exporters, and manufacturers through more precise terminology for describing varying gradations of quality. Prices would more accurately reflect value because grades established would reflect factors thought to be more relevant by buyers.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
3	3

TITLE: Physical and economic efficiency in marketing tobacco. RPA 504

SITUATION: Tobacco markets in the United States have operated basically in the same manner for the past 100 years with the market structure based on several warehouses at each market with each warehouse handling a relatively limited quantity of tobacco. Very little mechanization or changes in market labor techniques have occurred in the past 100 years. While marketing of other field crops has streamlined, tobacco markets are unique in maintaining the status quo. Hand labor performs virtually all the handling operations occurring within the market structure.

OBJECTIVE: Reduce unit costs of marketing tobacco and maintain its high quality, through better handling methods, equipment, packaging, storage, conditioning procedures, efficiency in marketing and subsequent operations.

RESEARCH APPROACHES:

A. Delineate organizational and management practices in relation to cost of marketing tobacco.

B. Determine the relationship between warehouse size and costs for marketing tobacco.

C. Determine location of warehouses and redryers which will minimize total marketing and redrying costs.

D. Develop systems of moving tobacco from areas of production to marketing areas in a way to minimize marketing and processing costs.

E. Evaluate relationship of plant layout, and handling methods for receiving, storing, selling, and loading out on market quality and marketing costs.

F. Develop new or improved equipment for receiving, grading, selling, and loading out in auction warehouses to improve the quality of the product and reduce marketing costs.

G. Analyze the effect of alternative handling methods and equipment on transportation equipment design and performance on green prizing and processing costs.

H. Develop packaging and transportation methods and techniques to provide convenient receiving, grading, selling, load out, and transportation to processing plant with less loss of product and at lower costs.

I. Develop improved methods and equipment for conditioning, handling, and storage of tobacco in processing plants.

J. Coordinate with RPA 408 and 501.

CHARACTER OF POTENTIAL BENEFITS: To improve quality of tobacco purchased by tobacco companies and reduce selling costs.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
5	7